

## Redescription of *Phyllidia coelestis* Bergh, 1905 (Opisthobranchia : Nudibranchia : Doridoidea)

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### ABSTRACT

*Phyllidia coelestis* Bergh, 1905 is redescribed. *Phyllidia alia* Yonow, 1984 is recognized as a junior synonym. *P. coelestis* has been confused with *P. elegans* Bergh, *P. nobilis* Bergh and *P. varicosa* Lamarck in the past. Internal anatomy is detailed for the first time and the morphology of the penial spines is advanced as a useful additional character for the description of *Phyllidia* species. *P. coelestis* is shown to be widespread in the tropical Indo-Pacific.

### INTRODUCTION

The taxonomy of nudibranchs belonging to the family Phyllidiidae is presently in a chaotic state. Many recent authors have commented on this fact (Wägele, 1985; Yonow, 1986; Brunckhorst and Willan, 1989; Gosliner and Behrens, 1988). Brunckhorst and Willan (1989) have reviewed the Mediterranean species of *Phyllidia*. This paper reviews one of the tropical Indo-Pacific species of *Phyllidia*.

Bergh (1905) described *Phyllidia coelestis* from a 32 mm specimen collected on a reef-flat near Saleyer, Indonesia, during the "Siboga" expedition. Bergh gave a short description of the living animal noting particularly the absence of a longitudinal, dark line on the foot sole. The only anatomical notes referred to the oesophagus as whitish-yellow: "its form typical for *Phyllidia* and [the foregut] showed six short fingered swellings" (Bergh, 1905:182-183). A drawing of the living animal was also published in colour (Bergh, 1905, Plate 3 Fig. 16).

### MATERIAL AND METHODS

A total of seventy-eight live specimens and/or colour slides of living animals were examined. Table 1 was derived from these records (author's database) and the literature. Some material is deposited in the Australian Museum and the Western Australian Museum, and the registration numbers of these specimens are prefixed by AM and WAM respectively. The holotype of *P. coelestis* Bergh was examined. It is conserved in the "Siboga" expedition

collections of the Zoology Museum, Institute for Taxonomic Zoology, University of Amsterdam in Holland. The type material of *Phyllidia alia* Yonow from the British Museum (Natural History), registration numbers 198310 W/1 (holotype) and 198310 W/2 (paratype), were also examined.

The foregut of four specimens was sectioned for light microscope examination. The penial bulb was dissected from specimens which had been frozen prior to fixation in 5-10% buffered seawater formalin. In most cases the distal vas deferens, penial sheath and/or genital aperture had to be cut and the partially everted portion of the penis extracted by hydrostatic pressure or mechanically with fine needles. Drawings were made with the aid of a camera lucida.

The following material was dissected (if not acknowledged otherwise, specimens were collected by the author): i) One specimen (39 mm alive), 18 m depth, submerged reef patch off Lion Island, 15 km S.E. of Port Moresby, Papua New Guinea, 20 June 1988. ii) One specimen (30 mm alive), 4 m depth, submerged reef patch off Lion island, 15 km S.E. of Port Moresby, Papua New Guinea, 20 June 1988. iii) One specimen (33 mm alive), 12 m depth, S.E. front of Wistari Reef, Central Queensland, 1 December 1987. iv) Two specimens (37 mm, 32 mm alive), 10 m depth, Linnet Reef, W. of Lizard Island, North Queensland, 15 October 1986. v) One specimen (18 mm alive), 15 m depth, Macgillivray Reef, N.E. of Lizard Island, North Queensland, 16 October 1986. vi) One specimen (48 mm alive), 12 m depth, Batt Reef, North Queensland, 4 January 1987. vii) One specimen (33 mm preserved), 16-20 m depth, Uepi Island, Solomon Islands, leg. P. Chapman-Smith, 24 May 1987. viii) One specimen (41 mm alive), 6-30 m depth, Madang lagoon, Northern Papua New Guinea, leg. R. C. Willan, 16 February 1988. ix) Two specimens, AM C142660 (24 mm, 35 mm preserved), 20 m depth, off Dumaguete, Negros Island, Philippine Islands, leg. B. E. Picton, 3 March 1983. x) One specimen (9 mm alive), 6-12 m, "The Chimney", Madang lagoon, Northern Papua New Guinea, leg. R. C. Willan, 30 January 1988. xi) Two specimens, WAM 210-88 (31 mm, 27 mm preserved), Robray reef, North Western Australia, leg. F. Wells and C. Bryce, 15 July 1988. xii) One specimen, WAM 171-87 (42 mm preserved), Roly rock, Dampier, North Western Australia, leg. F. Wells and C. Bryce, 3 April 1987. xiii) Two specimens, WAM 239-88 (35 mm preserved) and WAM 240-88 (28 mm preserved), N. W. of Buffon Island, North Western Australia, leg. F. Wells and C. Bryce, 23 July 1988. xiv) Two specimens, WAM 1048-85 (37 mm, 27 mm preserved), 'Yardie creek', North Western Australia, leg. S. Slack-Smith and C. Bryce, 28 May 1981.

## DESCRIPTION

### FAMILY PHYLLIDIIDAE RAFINESQUE, 1814

#### *Phyllidia coelestis* Bergh, 1905

#### Synonymy

*Phyllidia coelestis* Bergh, 1905, p. 182, pl. 3, fig. 16; Eliot, 1906, p. 673; Pruvot-Fol, 1956, p. 64; Pruvot-Fol, 1957, p. 106; Kenny, 1970, p. 91; Burn, 1975, p. 516; Coleman, 1981, p. 157, pl. 472; Lin, 1983, p. 152, pl. 1, fig. 5.

*Phyllidia nobilis*: Farran, 1905, p. 345, pl. 3 figs. 16, 17. (non *Phyllidia nobilis* Bergh, 1869).

*Phyllidia elegans*: Edmunds, 1972, p. 82, fig. 4b. (non *Phyllidia elegans* Bergh, 1869).

*Phyllidia picta*: Burn, 1975, p. 516. (non *Phyllidia picta* Pruvot-Fol, 1957).

*Phyllidia alia* Yonow, 1984, p. 224, figs. 6c-d, 7a, 8f-g.

*Phyllidia varicosa*: Gosliner, 1987, p. 90, pl. 152. (non *Phyllidia varicosa* Lamarck, 1801).

### External Morphology

In life, the largest specimen measured 60 mm (average length was 33 mm). *P. coelestis* is broader than other *Phyllidia* species giving it a more oval than elongate appearance. The basic colours of *Phyllidia coelestis* are blue to grey-blue, gold, and black. The rhinophores are always gold-yellow. The foot is grey and has no other markings. Variation in colour and pattern are shown in Figure 1. The specimen illustrated in Figure 1a closely matches the holotype and Bergh's (1905) figure of *P. coelestis*. The mantle surface has three, longitudinal, black bands. Two black bands run laterally, each on the outside of two medio-lateral, blue-grey ridges which have tubercles tipped in gold. These ridges, which may be broken in some specimens, originate anteriorly

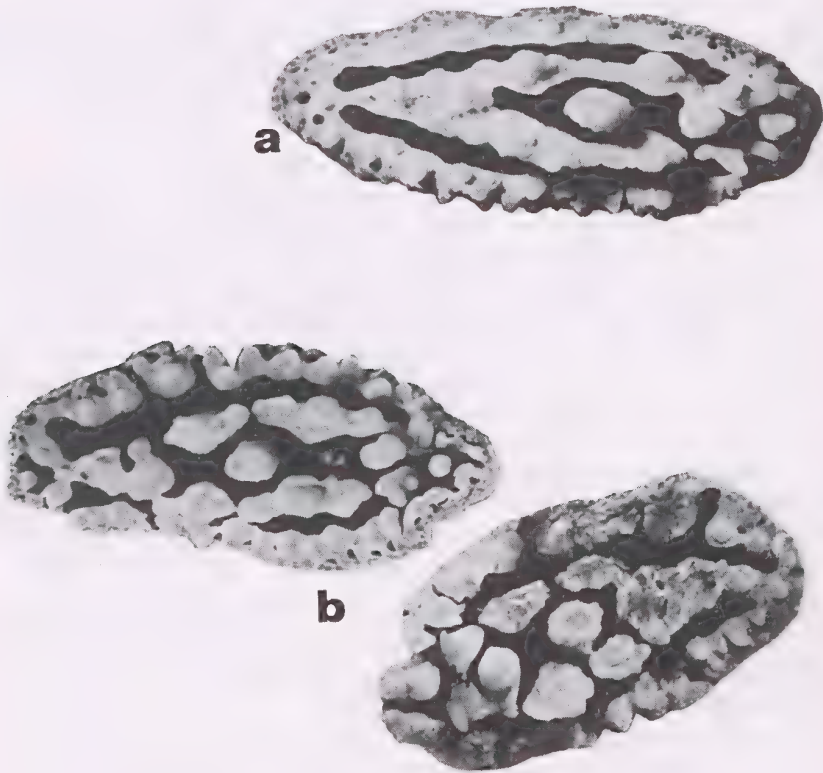


FIGURE 1. *Phyllidia coelestis* Bergh 1905. a. 39 mm specimen (alive), 18 m, reef patch off Lion Is., southern Papua New Guinea. Photograph: D. J. Brunckhorst. b. Variation in external pattern. Specimens (55 mm and 60 mm) found copulating, 13 m, Orontes reef, off Cobourg Peninsula, Northern Territory, Australia. Photograph: R. C. Willan.

immediately behind each rhinophore and converge posteriorly in the region of the anus. Two to four isolated, large, gold capped tubercles arise from the median black band; however, these are never joined as a midline ridge. There are always two isolated gold-tipped tubercles in the midline, one immediately anterior to, and the other immediately posterior to, the rhinophores (Fig. 1). The rhinophores are gold-yellow in colour and each clavus possess 19 to 26 lamellae. Around the edge of the mantle is a wide, blue-grey strip having smaller tubercles, the larger ones of which may be gold tipped. Sometimes, meanderings of black encroach into this blue-grey margin (Fig. 1).

The pattern of juveniles appears to be simpler with less variation in the two ridges. These ridges are unbroken and form a distinctive "Y" shape on the mantle.

### **Anatomy**

There are two transverse, dark bands on the dorsal surface of the foregut, one at the junction of the oral tentacles and oral tube, and the other on the anterior section of the pharyngeal bulb (see Fig. 2).

The mouth, which is situated between the oral tentacles and the foot leads into an oral tube. The oral tube passes into a musculo-glandular pharyngeal bulb having cream coloured glandular bodies antero-ventrally (not visible in dorsal view of Fig. 2) which take the form of short rounded protuberances, some of which have short secondary branches. These glands correspond with Bergh's "short fingered swellings". Inside the pharyngeal bulb there is a thick, folded, glandular epithelium. This was particularly apparent in the sectioned material. Two large extrinsic retractor muscles insert postero-dorsally onto the pharyngeal bulb and are attached to the dorso-lateral body wall not more than one third of the way down the body length. The blood gland (folded to the left in Fig. 2) overlies the oesophagus and the reproductive organs. Posterior to the pharyngeal bulb, the pharynx narrows and forms the distinctive "Z" bend through the central nerve ring. From there, the oesophagus continues back into a large area of digestive gland which occupies about two-thirds of the body cavity. There is no distinct separation between the stomach and central core of the digestive gland. Instead, over a length of three to four millimetres, the oesophageal tube broadens into a thin walled tract. Here, there are lateral openings from the surrounding digestive gland. The exact number of these openings could not be ascertained because of the fragility of the organ.

The intestine originates dorsally from the posterior half of the digestive gland mass and passes forward before turning to the right, almost encircling the pericardium, and then straightening to run posteriorly down the right side to open dorsally via the anal papilla (Fig. 2).

The excretory system was not traced, although the position of the syrx is indicated in Figure 2. In some specimens, part of the nephridium was visible beneath the syrx and intestine.

### **Reproductive system**

The reproductive system displays the triaulic condition of the most advanced dorids. It has two allosperm receptacles (bursa copulatrix and

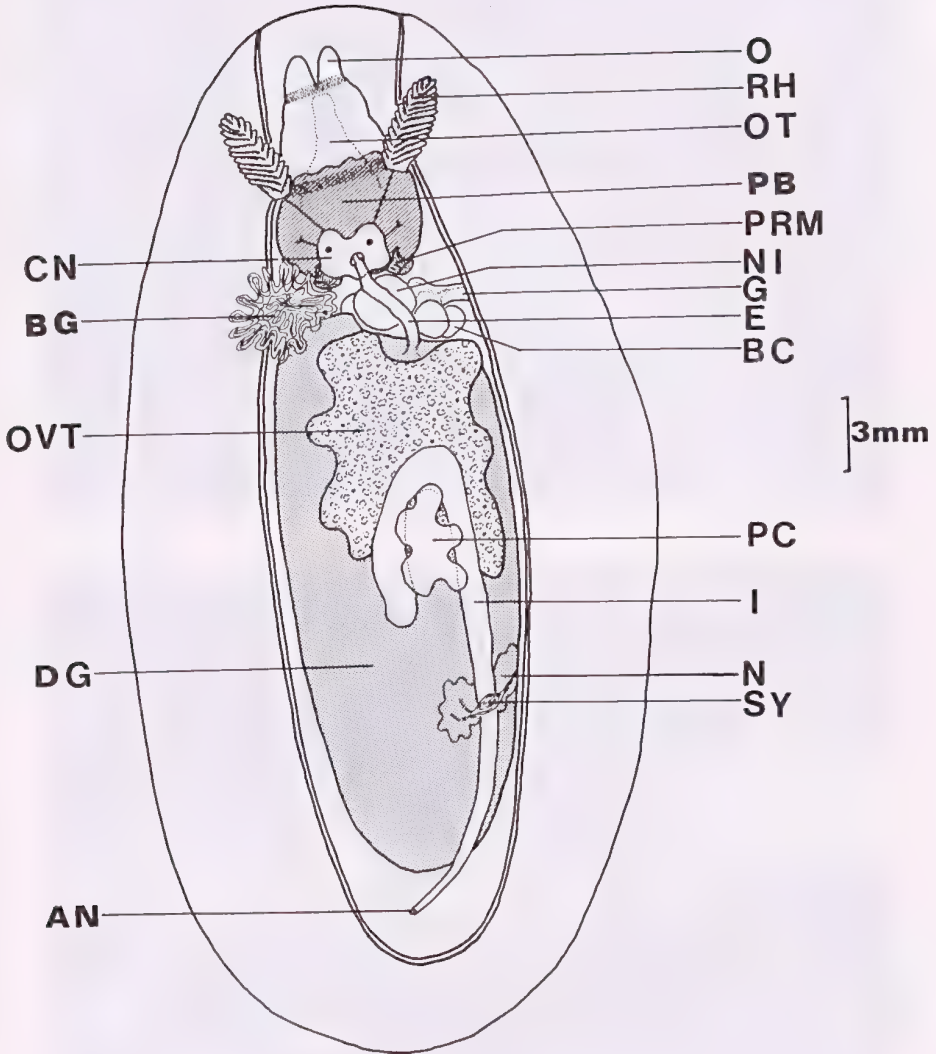


FIGURE 2. *Phyllidia coelestis*. Dorsal view of general anatomy. Abbreviations: AN -anus; BC -bursa copulatrix; BG - blood gland; CN - central nervous system; DG -digestive gland; E -oesophagus; G - reproductive opening; I -intestine; N -nephridium; NI - nidamental glands; O -oral tentacles; OT - oral tube; OVT - ovotestis; PB -pharyngeal bulb; PRM - pharyngeal retractor muscle; PC - pericardium; RH -rhinophores; SY - syrx.

receptaculum seminis -see Fig. 3). The ovotestis overlies the anterior third of the digestive gland. The remainder of the reproductive system occurs in the space between the pharyngeal mass (anteriorly) and the digestive gland (posteriorly), and opens laterally between the mantle and foot on the right side (Fig. 3). From the ovotestis, the hermaphrodite duct becomes a creamish coloured, oval ampulla. The short vas deferens leads from the ampulla into the prostate gland which, after a few bends, narrows as the distal vas deferens before opening directly into the muscular, ejaculatory duct (penis), which finally opens contiguously with the vagina (Fig. 3). The distal, slightly bulbous end of the eversible penis is armed with chitinous spines (Fig. 4) in 14 to 16 longitudinal rows separated by channels. Individual spines have a smooth surface, arise from a rounded base (viewed from above) which is not particularly broad in side view, are distinctly recurved, and taper to a pointed

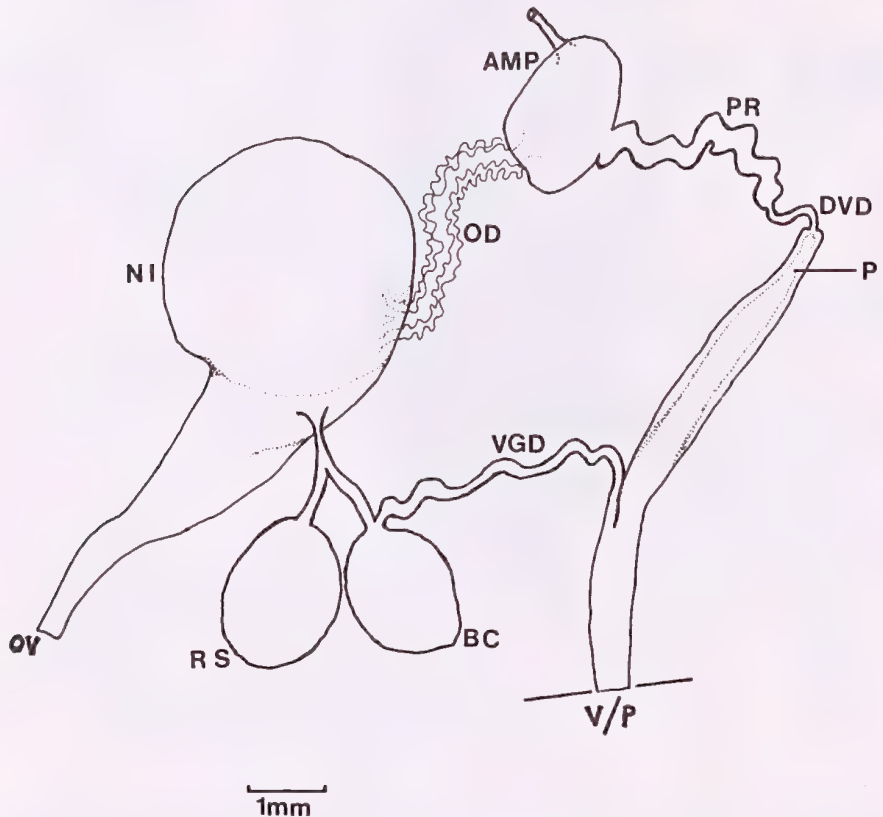


FIGURE 3. *Phyllidia coelestis*. Unraveled reproductive system. Abbreviations: AMP - ampulla; BC - bursa copulatrix; DVD - distal vas deferens; NI - nidamental glands; OD - oviduct; OV - oviducal aperture; P - penis; PR - prostate gland; RS -receptaculum seminis; VGD - vaginal duct; V/P - contiguous vaginal and penial aperture.

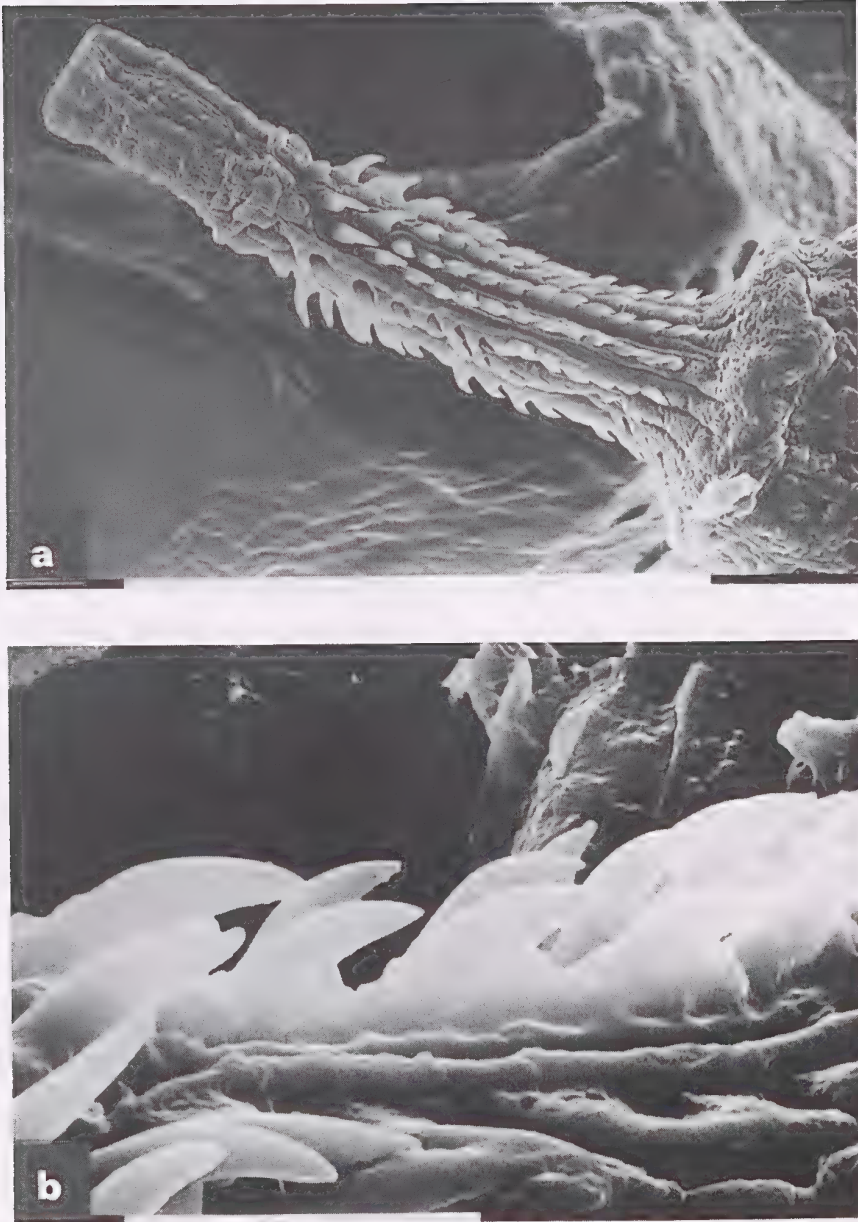


FIGURE 4. *Phyllidia coelestis*, scanning electron micrographs of penial armature. a. Completely everted penis. Scale bar 0.1 mm; b. Lateral view showing detail of penial spines. Scale bar 10  $\mu$ m.

end facing back towards the vas deferens (Fig. 4). The extreme tip of the penis is devoid of spines. In a 33 mm specimen, the distal segment of the penis without spines measured 40  $\mu\text{m}$ , the spinose region measured 76  $\mu\text{m}$ , and an individual spine was approximately 5 to 7  $\mu\text{m}$  in vertical height.

A thin walled, convoluted oviduct connects the ampulla to the nidamental gland mass. In situ, the vaginal duct and its two receptacles lies to the right of the nidamental glands (teased apart in Fig. 2) and the nidamental opening occurs immediately adjacent to the genital vestibule (= contiguous vaginal and penial aperture, Fig. 2). From the round, yellow-brown bursa copulatrix, the vaginal duct leads directly into the vagina. The oval receptaculum seminis is translucent. The vaginal duct divides just prior to the entry to each vesicle (Fig. 3). The genital vestibule is lined with folded epithelium which forms longitudinal ridges and canals, and these appear to match the rows of penial spines.

### Remarks

This work represents the first critical re-examination of *P. coelestis* since Bergh's (1905) original description. The species' tropical Indo-Pacific distribution has not been apparent previously (Table 1). *P. coelestis* is now known from the western Pacific, the South China Sea, the Timor Sea and across the Indian Ocean to South Africa. Records (present work) suggest that it is a more common species than previously considered.

Table 1. Biogeographic records for *Phyllidia coelestis*.

\* denotes new record.

Locality	Source
Indonesia (Celebes)	Bergh, 1905
South China Sea	Lin, 1983.
Solomon Islands*	Specimen & slide, P. Chapman-Smith, pers. comm., present work.
Papua New Guinea	Slide, C. Carlson, in litt., 1987; specimens, R. Willan, pers. comm., 1988; pers. obs., present work.
Vanuatu*	Slide, L. Thornton, in litt., 1985.
Fiji*	Specimens, R. Willan & G. Brodie, pers. comm., 1987.
Australia:	
Queensland	R. Kenny, 1970; R. Burn, 1975; AM specimens, present work.
Torres Strait*	Slide & pers. obs., 1985.
Northern Territory*	Specimens (Figure 1b), R. Willan, pers. comm., 1987.
Nth. Western Aust.*	WAM specimens, present work.
Sri Lanka*	Yonow, 1984, as <i>P. alia</i> .
Maldive Archipelago*	Slide, P. Chapman-Smith, pers. comm., 1984.
South Africa*	Edmunds, 1972, as <i>P. elegans</i> ; Gosliner, 1987, as <i>P. varicosa</i> .
Philippines*	AM specimens, present work.

*Phyllidia coelestis* is a distinctive species of *Phyllidia*. In the field it can usually be distinguished from other phyllidiids by colour and pattern, in particular the "Y" shape of the blue-grey, dorsal ridges, the gold capped, mid-dorsal tubercles (which never form a ridge as occurs in *P. varicosa* and *P. arabica*), the evenly tuberculate, grey-blue, mantle margin, gold rhinophores



and uniformly grey foot without a dark stripe (Bergh, 1905; present work). Colour photographs which illustrate these features of *P. coelestis* can be found in Coleman (1981:157, pl. 472) and Gosliner (1987:90, pl. 152 as *P. varicosa*). Internal characters reinforcing specific determination include the markings on the foregut and penial spine morphology. Although the pharyngeal bulb region is similar to that of *P. ocellata* and *P. varicosa* (in the possession of folded glandular tissue internally and the 'finger' glands on the ventral surface), the pharyngeal bulb is broader in *P. coelestis* and has anterior markings.

Scanning electron micrographs show that the penial spines of *P. coelestis* differ in size and shape to those of *P. varicosa* Lamarck and *P. pustulosa* Cuvier. For example, the penial spines of *P. varicosa* are broad based and taper in an even curve to their point (pers. obs.) whereas those of *P. coelestis* have a smaller, rounded base which narrows immediately resulting in a slimmer 'stem' to the spine. The penial spines of *P. pustulosa* are irregular in shape, slender, and more upright (pers. obs.). Although penial armature may be a useful additional taxonomic character, chemical signalling probably plays the crucial identification role and initiates copulatory behavior in nature (see Scheuer, 1977, 1982; Karuso, 1987). The 'keying' of penial armature with the lining of the vagina may (? or may not) be a secondary specific recognition factor after copulation is initiated.

*Phyllidia coelestis* has repeatedly been confused with other *Phyllidia* species in the literature. *P. varicosa* Lamarck and *P. arabica* Ehrenberg have three to five dorsal ridges including a mid-line ridge (Bergh, 1869, 1905; Yonow, 1986). In the absence of specimens for examination, Pruvot-Fol (1956, 1957) and Risbec (1956) erroneously considered *P. coelestis* to be a synonym of *P. varicosa*. Gosliner's (1987) *P. varicosa* can be identified as *P. coelestis*. However, the animal illustrated as *P. coelestis* by Lin (1975, pl.2, fig.9) is probably *P. varicosa*. Edmunds' (1972:82, fig.4b) *P. elegans* had no dark line on the sole and matches the dorsal pattern of *P. coelestis*. The *P. nobilis* specimen of Farran (1905) appears to be *P. coelestis* also. The specimen (WAM 90-64) referred to as *Phyllidia picta* Pruvot-Fol by Burn (1975) has been re-examined by Mr R. Burn and the present author, and we now both consider it to be *P. coelestis*. The holotype of *P. coelestis* was partially dissected by Bergh, but remains recognisable. *Phyllidia alia* Yonow, 1984 (with type locality of Sri Lanka) is a junior synonym of *P. coelestis*. Yonow's description of *P. alia* matches Bergh's (1905) precisely and my examination of the type material confirmed the synonymy.

#### ACKNOWLEDGEMENTS

I wish to thank Mr R. Moolenbeek (Amsterdam) for the loan of the *P. coelestis* holotype. Dr K. Jensen (Denmark) translated part of Bergh's monograph and arranged the loan of Bergh's other phyllidiid material for which I am most grateful. Dr N. J. Evans (BMNH) kindly arranged the loan of the *P. alia* type series. Dr W. B. Rudman (AM), Dr F. E. Wells and Mr C.

Bryce (WAM), and Dr R. C. Willan made additional material available. I am grateful to a number of other individuals (Table 1) who have sent me slides or specimens. I wish to thank the Director and staff of Motupore Island Research Station (University of Papua New Guinea) for their assistance and use of facilities. I thank Mrs L. Daddow (Zoology Dept.) and staff of the Electron Microscopy Department of the University of Queensland for advice and assistance. Dr R. C. Willan has given valuable advice and useful criticism for which I am most grateful. The manuscript has been improved by useful comments from Mr R. Burn, Mr C. Carlson, Dr W. B. Rudman and two anonymous referees. I am most indebted to my wife, Shireen, who assisted with collection and photography of specimens, collation of data, and preparation of the manuscript. The Hawaiian Malacological Society provided funds for field work, through their 1988 Scholarship Award.

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